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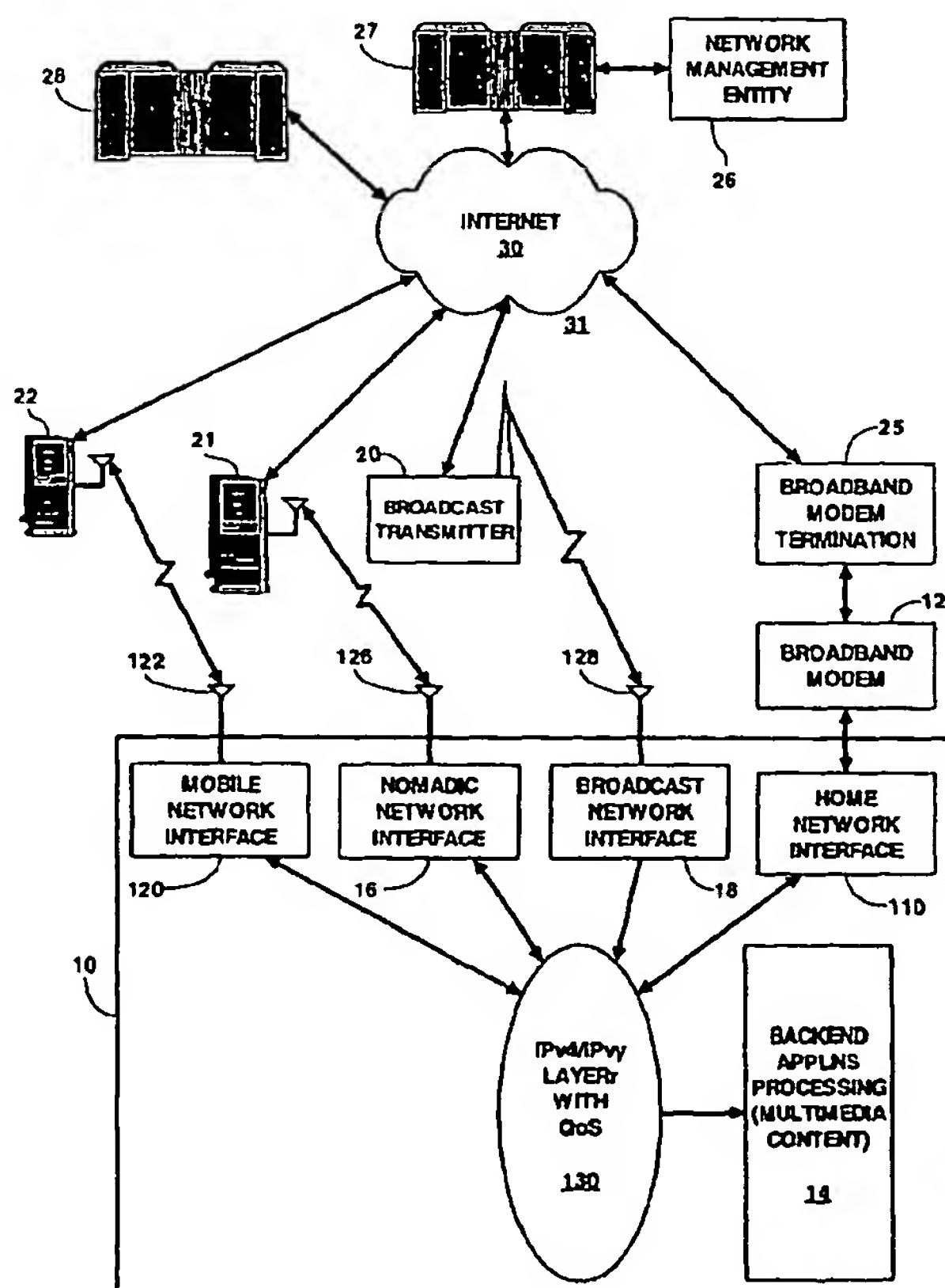
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[Continued on next page]

(54) Title: A MULTI-NETWORK MOBILE COMMUNICATION SYSTEM



(57) Abstract: A communication system for communicating via the Internet, includes a portable communications device, and a plurality of networks interconnecting, at least occasionally, the internet with the portable communications device. An intelligent content server is also interconnected to the Internet. A network management entity, is interconnected to the intelligent content server, and chooses which network is to be used for communicating between the intelligent content server and the portable communications device.

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1           **SEAMLESS COMMUNICATIONS THROUGH OPTIMAL NETWORKS**

2                           Field of the Invention

3           The present invention relates generally to mobile  
4   communications platforms and more specifically to  
5   communications optimization using an intelligent network  
6   selection.

7                           Background of the Invention

8           Mobile or cellular telephone devices are configured  
9   to communicate with a plurality of antennas, either  
10   ground or satellite based, which are ultimately connected  
11   to the traditional telephone system. Regardless of the  
12   specific path used there is a direct link between the  
13   cellular telephone and the telephone system communication  
14   network. Digital cellular telephone devices are further  
15   capable of transmitting to and receiving digital data  
16   from a digital data network, such as the Internet, with  
17   which the telephone system is interconnected. Such  
18   devices have been termed personal communications systems  
19   (PCS) devices. Such enhanced PCS devices can request,  
20   receive and display information from the internet such as  
21   maps, e-mail, text, web pages, audio and video files.

22           One problem associated with such enhanced  
23   capabilities is the bandwidth required to transmit such  
24   large volumes of data. Problems with scheduling and  
25   routing of data transmissions, as well as inefficient  
26   allocation of data transmission capacity, are present in  
27   many existing data communications networks. For example,  
28   the global interconnection of computer networks known as

29 the Internet routes data packets with the anticipation  
30 that the packets will eventually be delivered to the  
31 intended receiver but it is not uncommon for packets to  
32 be lost or delayed during transmission. Further, the  
33 internet does not differentiate between different types  
34 of data being transmitted.

35 Data packets requiring delivery within a certain  
36 time frame such as real time audio or video  
37 communications receive no preference in transmission  
38 over packets that generally do not require a particular  
39 time of delivery, such as electronic mail. Data packets  
40 carrying important information in which packet loss  
41 cannot be tolerated, such as medical images, receive no  
42 greater priority than other data packets. Because all  
43 data packets are viewed as equally important in terms of  
44 allocating transmission resources, less critical  
45 transmissions such as e-mail may serve to delay or  
46 displace more important and time sensitive data.

47 Capacity for data transmission in existing data  
48 communications networks is often inefficiently allocated.  
49 In some instances transmission capacity or bandwidth is  
50 allocated to a particular user according to a fixed  
51 schedule or particular network architecture, but the  
52 available bandwidth is not actually used. In other  
53 instances, a user is precluded from transmitting a burst  
54 of data that, for the moment, exceeds the user's  
55 bandwidth allocation. Existing data communications  
56 networks often lack mechanisms whereby bandwidth may be  
57 allocated on demand.

58       The current cellular telephone system uses  
59       relatively low bandwidth signaling techniques on the  
60       order of fifty kilobits per second. Graphical  
61       information such as maps and pictures require relatively  
62       wide bandwidths in order to achieve reasonable response  
63       times. Video and audio files require even higher  
64       bandwidths for adequate response times. With limited  
65       spectrum resources, the cost of bandwidth on a relatively  
66       narrow band network can be high.

67       Current television signal broadcasting systems  
68       provide relatively wide bandwidth capability on the order  
69       of twenty megabits per second for each six megahertz  
70       wide television channel. Terrestrial frequency bands in  
71       the United States include almost four hundred megahertz  
72       of available spectrum. Terrestrial broadcast channels  
73       typically have a reception radius of approximately  
74       seventy miles, dependent largely on local terrain.

75       Direct digital satellite television broadcasting  
76       systems can also provide digital channels which can be  
77       used for digital information transmission. An example of  
78       such a system is disclosed in United States Patent No.  
79       6,366,761, entitled PRIORITY BASED BANDWIDTH ALLOCATION  
80       AND BANDWIDTH ON DEMAND IN A LOW EARTH ORBIT SATELLITE  
81       DATA COMMUNICATIONS NETWORK, issued on April 2, 2002 to  
82       Montpetit. Digital data from these channels are  
83       receivable over a much wider area typically including  
84       tens of thousands of square miles. These channels are  
85       not completely used. Thus there is a vast amount of  
86       unused television broadcast spectrum available for other  
87       uses.

88           Some data which will be requested by a user of a PCS  
89 device will be unique to that user, such as an e-mail  
90 addressed only to that user. Other data will be of  
91 simultaneous interest to a large number of users, such  
92 as weather data or stock market quotations. Other  
93 information will be of widespread simultaneous interest  
94 only at certain times, such as IRS tax forms during the  
95 second week of April. The Internet and the associated IP  
96 protocols will be expected to enable the increasing  
97 demand for data. Network connectivity can be established  
98 through a variety of means including connecting to a  
99 broadband modem (cable, DSL or satellite) through wired  
100 or wireless means, or by connecting to a nomadic network  
101 such as offered by wireless LAN standards, or by  
102 connecting to a mobile network. Current bandwidth for  
103 cellular telephone devices is barely sufficient to  
104 provide unique information to a particular PCS device as  
105 such information is requested, and more efficient methods  
106 of accessing the appropriate network for the bandwidth  
107 actually needed must be found if all of the available  
108 bandwidth is not to become exhausted by the increasing  
109 number of users.

110           Within a single network the mechanism or protocol  
111 needed to connect to that network in order to obtain a  
112 range of services is a straightforward problem with known  
113 solutions. However, when one must traverse between  
114 different networks the problem of making a seamless  
115 transition is substantial. For example, in second  
116 generation cellular networks it is often possible to  
117 connect to a different network on a per session basis.

118           Unfortunately, the possibility of optimizing  
119   bandwidth at the packet level is not available because  
120   the mechanism for communicating across networks has no  
121   common protocol layer. In the Internet, the commonly  
122   used protocol is termed IPv4 which has a set of tools  
123   that enables mobility management. These set of protocols  
124   are termed Mobile IP protocols. Several enhancements  
125   to the IPv4 protocols have resulted in a second  
126   generation termed IPv6. In addition to an expanded  
127   address space of 128 bits instead of the 32 bits used by  
128   IPv4, there are several features that enable better  
129   mobility management. Mobility can be managed by using  
130   the static IP addressing schemes in IPv6. In IPv4, due  
131   to the scarcity of address space, dynamic and local IP  
132   address assignment is often used. The efficiency of  
133   address management is expected to be better in IPv6 which  
134   will result in better service overall. An example of a  
135   mobile system using IPv6 is disclosed in United States  
136   Patent No. 6,172,986, entitled MOBILE NODE, MOBILE AGENT  
137   AND NETWORK SYSTEM, issued to Watanuki et al. on January  
138   9, 2001.

139           Data requested by the user may be of a time critical  
140   nature and need to be delivered with strict time  
141   constraints. Alternatively, data may also be downloaded  
142   with less severe time constraints. The former calls for  
143   Quality of Service (QoS) constraints that need to be  
144   supported by the network. The latter is the typical  
145   download model for Internet content and is termed a best-  
146   effort delivery. Finally, data may also be delivered  
147   with a time delay. Examples could include music or  
148   multimedia which the user wishes to view at a later time.



149 This category represents the most flexibility afforded  
150 from a network optimization and usage viewpoint.

151       Given the existence of the many networks, bandwidths  
152 and accessibility variables briefly alluded to in the  
153 foregoing, a need exists for a mechanism that allows the  
154 user to seamlessly roam or transition between these  
155 networks, based on a calculation of the needed bandwidth,  
156 message priority, and bandwidth cost, such that the  
157 minimum required bandwidth at the lowest cost is always  
158 selected.

#### 159                   Summary of the Invention

160       In accordance with the principles of the present  
161 invention, a communication system for communicating via  
162 the Internet, includes a portable communications device,  
163 and a plurality of networks interconnecting, at least  
164 occasionally, the internet with the portable  
165 communications device. An intelligent content server is  
166 also interconnected to the Internet. A network  
167 management entity, is interconnected to the intelligent  
168 content server, and chooses which network is to be used  
169 for communicating between the intelligent content server  
170 and the portable communications device.

171       In such a communications system, the problem of  
172 optimizing network selection by choosing the most cost  
173 effective available bandwidth is addressed by  
174 implementing the portable communications device as a  
175 portable intelligent multiple network platform. The  
176 platform includes multiple front end interfaces, with  
177 each interface corresponding to a type of available



178 network, such as a home network interface, broadcast  
179 network interface, nomadic network interface and a mobile  
180 network interface. The home network interface is  
181 typically plugged into a broadband modem, while the other  
182 interfaces utilize an antenna terminal to perform  
183 wireless communications.

184       Within the platform each network interface is  
185 interconnected to a network data processing layer capable  
186 of transmitting and receiving data via either the IPv4 or  
187 IPv6 protocol. For large files requiring substantial  
188 bandwidths, such as multimedia applications, the network  
189 data processing layer is interconnected to a discrete  
190 backend applications processor which processes and  
191 buffers the data stream.

192       Each network interface transmits to and receives  
193 data from a base station or network termination dedicated  
194 to that particular type of network. In turn, each such  
195 base station or termination has an appropriate connection  
196 to the Internet. Also connected to the Internet is an  
197 intelligent content server which is interconnected to a  
198 network management entity. In order for the intelligent  
199 content server to communicate with the portable  
200 intelligent multiple network platform, the platform  
201 registers into any of the available networks through any  
202 physical layer having a return channel.

203       The platform can function with the existing mobile  
204 IPv4 protocols or can use the static IPv6 global  
205 addressing scheme. The platform communicates with the  
206 intelligent content server and informs the server of its  
207 current IP address and its current specific multi-

208 networking capabilities. The intelligent network  
209 management entity chooses the appropriate network to use  
210 for each packet which is to be transmitted or received  
211 based on optimizing criteria such as priority, desired  
212 transmission quality, required bandwidth and cost.

213       When the portable platform leaves the current  
214 network within which it is operating (typically due to  
215 physically travelling beyond the range of the current  
216 network), the portable platform automatically searches  
217 for and tries to connect to the next best (based on the  
218 optimization criteria) network. When a new connection is  
219 successfully accomplished, the portable platform sends  
220 information to the network management entity regarding  
221 its current connection. In response to this information,  
222 the intelligent network management entity routes  
223 subsequent packets through the newer optimum network  
224 route. This process can be managed at either a per-  
225 packet or per-session level.

#### 226               Brief Description of the Drawings

227       Figure 1 is a block diagram illustrating portable  
228 communications network selection optimizing system  
229 according to the principles of the present invention; and

230       Figure 2 is a block diagram of a personal  
231 communications system device according to the principles  
232 of the present invention, which may be used in the system  
233 as illustrated in Figure 1.

234 Detailed Description of the Invention

235 Figure 1 is a block diagram of a mobile  
236 communications system including a multiple network  
237 portable platform 10 which is capable of bidirectional  
238 transmission and reception with either a broadband modem  
239 12 or with any of a plurality of wireless communications  
240 networks via antennas 122, 126 and 128. In practice the  
241 antennas 122, 126 and 128 may be a single physical  
242 antenna with appropriate matching networks or it may be  
243 one or more antennas in close physical proximity. The  
244 antenna 122, for example, is responsive to digital  
245 cellular telephone signals from, for instance, a cellular  
246 telephone mobile network termination or base station 22.  
247 The antenna 122 is bidirectionally coupled to a mobile  
248 interface circuit 120.

249 As also seen in Figure 2, the mobile interface  
250 circuit 120 is coupled to a direct data input terminal of  
251 a microprocessor 118. A direct data output terminal of  
252 the microprocessor ( $\mu$ P) 118 is coupled to an input  
253 terminal of the mobile interface 120. An audio output  
254 terminal of the microprocessor 118 is coupled to an input  
255 terminal of the speaker 114. An output terminal of a  
256 microphone 112 is coupled to an audio input terminal of  
257 the microprocessor 118. An output terminal of a keypad  
258 116 is coupled to a control input terminal of the  
259 microprocessor 118.

260 The microprocessor operates in a known manner under  
261 the control of an application program stored in memory  
262 such as a Read Only Memory (ROM) in the microprocessor

263 118. In particular, the microprocessor is programmed to  
264 operate as a data processing layer 130 utilizing the both  
265 the current Internet Protocol version 4 (IPv4) and the  
266 still developing next generation Internet Protocol  
267 version 6 (IPv6). The layer 130 may include a Quality of  
268 Service (QoS) program as is well known to those of  
269 ordinary skill in this field.

270 The microprocessor 118 also includes a backend  
271 applications processor 14 which is capable of  
272 bidirectional communication with the Internet Protocol  
273 layer 130. The processor 14 serves as a buffer and  
274 decoder for data received by microprocessor 118, and is  
275 particularly useful for processing data having a  
276 multimedia content such as audio and video files. The  
277 backend processor 14 may also be a discrete circuit or  
278 combination of integrated circuits that are external to  
279 the microprocessor 118 but which are still mounted on the  
280 multiple network portable platform 10.

281 The platform 10, as described above, operates in a  
282 known manner to allow a user to make telephone calls.  
283 The user manipulates the keys on the keypad 116 to  
284 instruct the microprocessor 118 to cause the mobile  
285 interface circuit 120 to connect to an external network,  
286 such as the Internet 30, or a mobile telephone  
287 communications network via the mobile base station 22.  
288 The keypad 116 generates dialing tones specifying the  
289 desired telephone number or instructional code.  
290 Alternatively, signals may be received from the Internet  
291 30 or from the cellular telephone network indicating that  
292 someone is attempting to call the portable platform 10.

293 In response to these signals, the microprocessor 118  
294 conditions the mobile interface circuit 120 to connect to  
295 the network and complete the call.

296 In either event, signals representing spoken  
297 information from the microphone 112 are digitized by the  
298 microprocessor 118, and the digitized signal is  
299 transmitted through the mobile interface 120 and the  
300 antenna 122 to the mobile network base station 22.  
301 Simultaneously, signals received by the antenna 122 from  
302 the base station 22, and representing received digitized  
303 speech information from the other party, are received by  
304 the mobile interface 120, converted to a sound signal by  
305 the microprocessor 118 and supplied to the speaker 114.

306 As described above, the multiple network platform 10  
307 also provides the capability of requesting and receiving  
308 information from a computer, typically via the internet.  
309 Data representing requested information may be generated  
310 by the user from the keypad 116, which may have more keys  
311 than illustrated in Figure 2. The information request  
312 is supplied by the microprocessor 118 to any of the  
313 network interfaces available on the network platform 10.  
314 For example, the platform 10 may include not only a  
315 mobile interface 120, but also a home network interface  
316 110, a nomadic network interface 16, and a broadcast  
317 network interface 18. Depending on which network is  
318 available for use, the information request is transferred  
319 to either a broadband modem 12 or one of the antennas  
320 122, 126 or 128.

321 Regardless of the network in use at a particular  
322 time, the information request is transmitted to the

323 Internet 30. Also supplied by the common layer 130 is a  
324 status report regarding which of the network interfaces  
325 16, 18, 110 and 120 is currently in communication with  
326 its associated network. Each of these networks will have  
327 unique characteristics associated with its particular  
328 network path. These characteristics will include the  
329 bandwidth of the network path, the monetary cost of using  
330 the network, the data transmission speed available, the  
331 quality and reliability of the network, the geographic  
332 coverage of the network and the type of data best suited  
333 for transmission via the particular network path. By  
334 transmitting the current universe of network  
335 availability, a recipient may be able to select the most  
336 appropriate network for transmission of return data.

337 The information transmitted by platform 10 to the  
338 Internet 30 will be received by a server machine such as  
339 intelligent content server 27 which contains the  
340 information desired by the user of the portable platform  
341 10. Interconnected to the content server 27 is a network  
342 management entity 26 which receives the network  
343 availability or status report from platform 10. The  
344 management entity 26 is programmed to optimize the  
345 selection of the network via which its associated content  
346 server 27 will transmit and receive data to and from the  
347 platform 10.

348 There exist two possible modes of transmitting the  
349 desired information from the server 27. The first mode  
350 is a *unicast mode* in which the server's data is intended  
351 only for a specific user's platform 10. The second  
352 possible mode is a *multicast mode* in which the server's



353 data is intended for simultaneous transmission to a  
 354 plurality of platforms 10.

355 In either case the objective of the server 27 is to  
 356 transport  $P$  packets to the platform 10 by routing the  
 357 data through the backbone or internal structure of the  
 358 internet 30 to the "edge" 31 of its global computer  
 359 network, and to continue the data transmission from the  
 360 edge 31 across the chosen communications access network  
 361 20, 21, 22 and/or 25 to the platform 10.

362 In order for the network management entity 26 to  
 363 optimize its choice of a particular network from the  
 364 universe of available networks, the goal for the unicast  
 365 mode is to minimize the expression:

$$366 \quad \text{Minimize} \left[ P_j \sum_i ((x_i + y_i) N_i) \right] \text{ subject to } \sum_j P_j = P$$

367 where

368  $x_i$  is the cost of transporting each data packet  
 369 through the internet 30 to its edge 31 for the  $i$ th access  
 370 line;

371  $y_i$  is the cost of transporting each packet through  
 372 the respective access networks, e.g. 20, 21, 22, 25;

373  $P_j$  is the number of packets transported on link  $i$ ;

374 and

375  $N_i$  is the number of users on the  $i$ th link requesting  
 376 the content of server 27.

377 The unicast expression can be solved as an  
 378 optimization problem using standard optimization  
 379 techniques, which will result in reducing the cost of



380 transporting each packet through the entire network, that  
381 is, through the internet 30 and through the following  
382 communications network 20, 21, 22 or 25. To enable  
383 quality of service, the cost structure for each segment,  
384  $x_i$  and  $y_i$  used earlier are appropriately reflected and  
385 the optimization problem is solved with the new numbers.

386 For the multicast case, the goal is to minimize the  
387 following expression:

388 
$$\text{Minimize}_j \left[ P_j \sum_i (x_i + y_i) \right] \text{ subject to } \sum_j P_j = P$$

389 This expression is identical to the unicast mode  
390 except that the penalty incurred for multiple users  
391 requesting server content ( $N_i$ ) is removed. This  
392 expression also can be optimized using well known  
393 optimization techniques. Each optimization may be  
394 performed on either a per packet or per session basis.

395

## 1 CLAIMS

2 1. A communication system for communicating via the  
3 Internet, comprising:  
4 a portable communications device;  
5 a plurality of networks, each network inter-  
6 connecting, at least occasionally, the internet with the  
7 portable communications device;  
8 an intelligent content server, the content server  
9 being interconnected to the Internet; and  
10 a network management entity, the network management  
11 entity being interconnected to the intelligent content  
12 server, the network management entity choosing which  
13 network is to be used for communicating between the  
14 intelligent content server and the portable  
15 communications device.

1

1 2 The communications system of claim 1, wherein the  
2 portable communications device comprises a plurality of  
3 network interfaces for establishing a communications link  
4 with each of the plurality of networks, respectively.

1

1 3. The communications system of claim 2, wherein the  
2 portable communications device further comprises a  
3 microprocessor programmed to process data via any of the  
4 network interfaces.

1

1 4. The communications system of claim 3, wherein the  
2 network management entity is programmed to choose the  
3 network to be used for communicating with the portable  
4 device based on available bandwidth of each of the  
5 plurality of networks.

1

1 5. The communications system of claim 4, wherein the  
2 network management entity evaluates a cost associated  
3 with each network when choosing the network to be used  
4 for communicating with the portable communications  
5 device.

1

1 6. The communications system of claim 5, wherein the  
2 network management entity evaluates a quality-of-  
3 transmission value associated with each network when  
4 choosing the network to be used for communicating with  
5 the portable communications device.

1

1 7. The communications system of claim 6, wherein the  
2 network management entity evaluates the network to be  
3 used for communicating with the portable communications  
4 device for each data packet to be transmitted between the  
5 intelligent content server and the portable  
6 communications device.

1

1 8. The communications system of claim 6, wherein the  
2 network management entity evaluates the network to be

3 used for communicating with the portable communications  
4 device for each data transmission session.

1

1 9. The communications system of claim 8, wherein the  
2 microprocessor is programmed to transmit all information  
3 to and from each network interface by using a common  
4 Internet protocol layer.

1

1 10. The communications system of claim 9, wherein the  
2 microprocessor is programmed:  
3 to determine which of the plurality of networks is  
4 operational;  
5 to transmit information representing which of the  
6 plurality of networks is operational to the network  
7 management entity.

1

1 11. A data transmission optimization system for use in  
2 multi-network environments, comprising:  
3 an intelligent content source (27);  
4 an intelligent network management entity (26)  
5 interconnected to the intelligent content source;  
6 a multi-network platform (10) interconnected to a  
7 plurality of communications networks, the multi-network  
8 platform transmitting a communications network status  
9 report to the intelligent management entity, the  
10 intelligent management entity selecting a communications  
11 network (20, 21, 22, 25) for transmission of data from

12 the intelligent content source to the multi-network  
13 platform.

1

1 12. The data transmission optimization system of claim  
2 11 wherein the intelligent management entity selects one  
3 of the communications networks based on an optimization  
4 algorithm that includes network bandwidth as a variable.

1

1 13. The data transmission optimization system of claim  
2 11 wherein the optimization algorithm evaluates network  
3 cost of data transmission as a variable.

1

1 14. The data transmission optimization system of claim  
2 11 wherein the optimization algorithm evaluates network  
3 quality of data transmission as a variable.

1

1 15. The data transmission optimization system of claim  
2 11 wherein the intelligent management entity selects one  
3 the communications networks for each data transmission  
4 session with the multi-network platform.

1

1 16. The data transmission optimization system of claim  
2 11 wherein the intelligent management entity selects one  
3 of the communications networks for each data packet  
4 transmitted to the multi-network platform.

1 17. A method of optimizing data transmission between a  
2 portable platform and an intelligent content server by  
3 optimizing a communications network selection in a multi-  
4 network environment, comprising the steps of:  
5 determining which communications networks are  
6 connected to the portable platform;  
7 transmitting a communications network status report  
8 to the intelligent content server;  
9 causing a network management entity to evaluate  
10 characteristics of the communications networks connected  
11 to the portable platform; and  
12 causing the network management entity to select a  
13 communications network based on the evaluated  
14 characteristics; and  
15 transmitting data from the intelligent content  
16 server to the portable platform via the selected  
17 communications network.

1

1 18. The method of claim 17, further comprising the step  
2 of evaluating characteristics of the communications  
3 networks for each data transmission session.

1

1 19. The method of claim 17, further comprising the step  
2 of evaluating characteristics of the communications  
3 networks for each data packet to be transmitted.

1

1 20. The method of claim 17, wherein data is transmitted  
2 from the intelligent content server to the portable  
3 platform via a common internet protocol layer

1

1



1/2

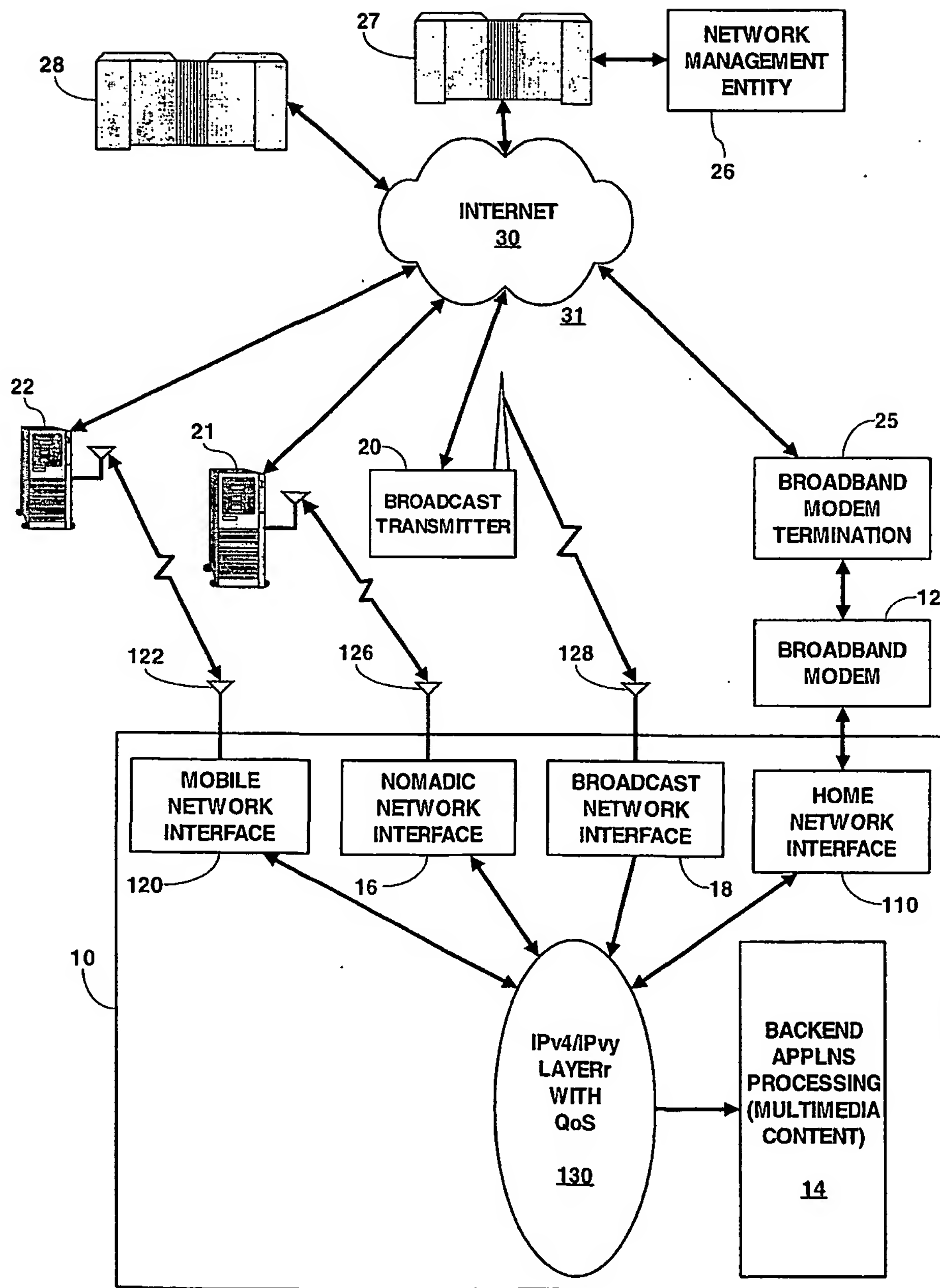


Fig. 1 – System

2/2

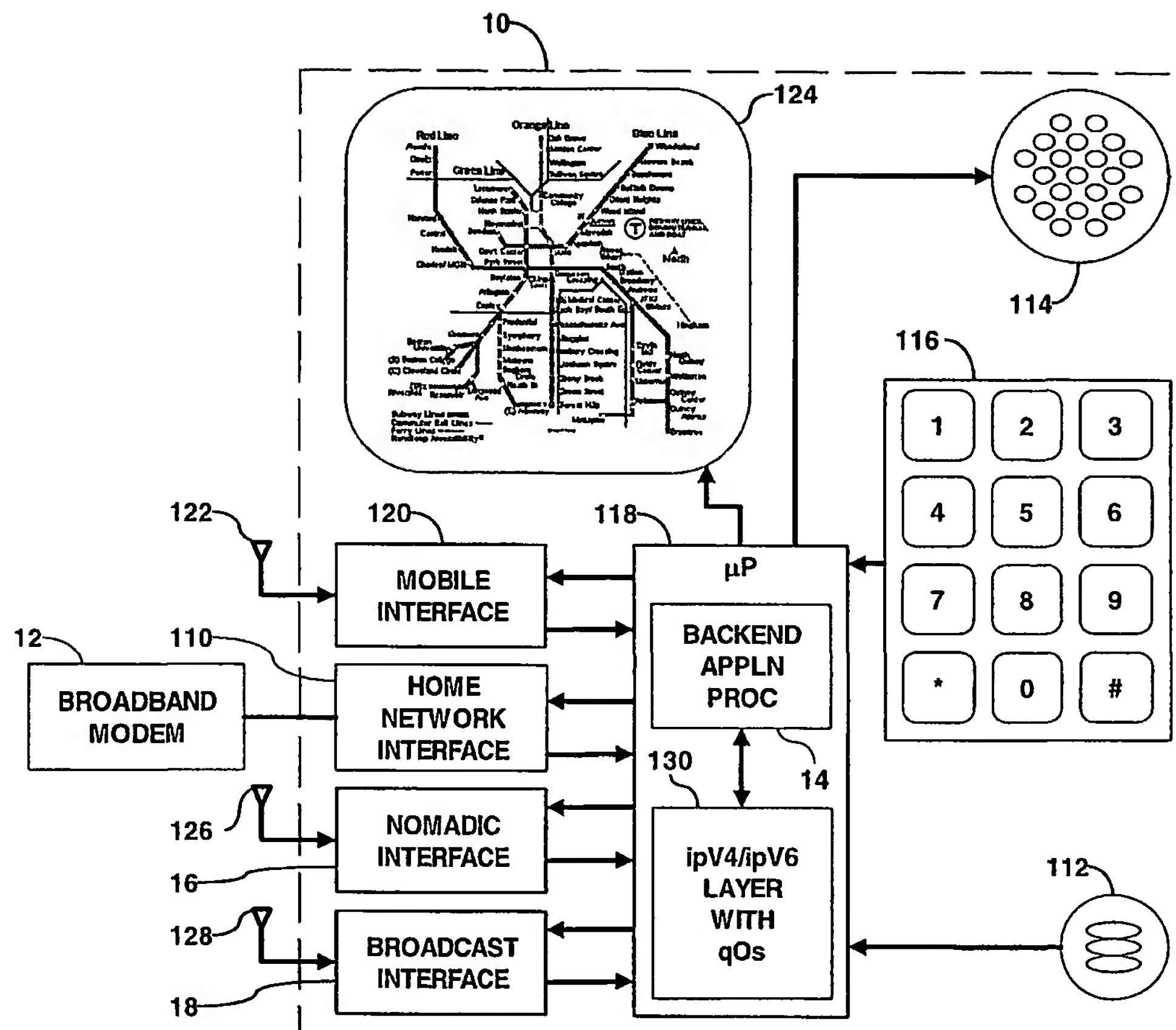


Fig. 2 - Terminal